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APPLE SPRAYING EXPERIMENTS IN 1914.

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BULLETIN 240.

APPLE SPRAYING EXPERIMENTS IN 1914.

W. J. MORSE AND M. SHAPOVALOV.

While in many respects the problem of controlling apple scab by spraying has long since become merely a matter of demonstration, there are still certain phases of it, both from a scientific and a practical standpoint which require much additional study. In order to secure data applicable to Maine conditions this Station is conducting a series of apple spraying experiments at Highmoor Farm, Monmouth. That this is important and that it is not always safe to generalize too freely in adopting locally the conclusions derived from results obtained in widely separated parts of the country, under different climatic conditions, is shown later in this publication.

In carrying out work of this kind it is necessary to introduce certain experiments, in order to provide a base line upon which to draw conclusions, which if considered by themselves would be simply of the nature of a demonstration. It has also seemed important to those who have had the planning of these experiments in charge that they be outlined so as to cover an indefinite series of years, that is, continued for a sufficiently long period to secure accuracy of results, or in other words to eliminate as far as possible inaccuracies resulting from abnormalities in climatic conditions of individual seasons. The experiments in question have been carried out each year in the same part of the smaller of the two large Ben Davis orchards on the farm, although the number of trees involved has varied considerably from season to season.

THE 1914 EXPERIMENTS.

The number of trees involved in the 1914 experiments was 282, somewhat more than the previous year, all of the Ben Davis variety. In laying out the plots the trees were selected

so as to make 47 rows of 6 trees to the row. With the exception of plot 1 which was made up of 3 rows or 18 trees, each plot consisted of 24 trees in 4 parallel rows.

The trees under experiment are now in a very thrifty condition, for they have received good care for the past 5 years. Some renovation work was done on them in 1909, but previous to that for several years they had been badly neglected. On account of increasing the number of plots it has been necessary to utilize some trees which were less thrifty than the average in this part of the orchard when the Station took charge of the farm and which are consequently still somewhat inferior to the others. In 1914 this more particularly applied to plots 11 and 12, and to a less extent to plots 8, 9 and 10.

TREATMENT OF THE PLOTS.

The following is the spraying treatment outlined for each separate plot. The dates of application are given on page 182.

- Plot 1. Bordeaux mixture, 3-3-50 formula, plus one pound of dry arsenate of lead to 50 gallons.
- Plot 2. First application like plot 1; later applications 2 pounds of dry arsenate of lead to 50 gallons of water.
- Plot 3. First application lime-sulphur 20 per cent stronger than standard dilution* plus one pound of dry arsenate of lead in 50 gallons; later applications like plot 2.
- Plot 4. Standard dilution lime-sulphur plus one pound of dry arsenate of lead in 50 gallons.
- Plot 5. Like plot 4 with the first application omitted.
- Plot 6. "Soluble sulphur" three-fourths pound and one pound of dry arsenate of lead in 50 gallons of water.
- Plot 7. "Atomic sulphur" 7 pounds and one pound of dry arsenate of lead in 50 gallons of water.
- Plot 8. Standard dilution lime-sulphur plus 2 pounds of copper sulphate and one pound of dry arsenate of lead in 50 gallons.

*By standard dilution is meant the equivalent of a 1 to 40 dilution of a 33° Baumé lime-sulphur concentrate. For a 20 per cent stronger dilution, one-fifth more of the concentrate was used for making a given amount of spray than was used for making the standard dilution.

- Plot 9. Extra fine sulphur 10 pounds plus one pound of dry arsenate of lead in 50 gallons of water.
- Plot 10. Lime-sulphur 20 per cent stronger than standard dilution plus one pound of dry arsenate of lead in 50 gallons.
- Plot 11. Two pounds of dry arsenate of lead alone in 50 gallons of water.
- Plot 12. Unsprayed check.

Plots 1, 4, and 12, sprayed with bordeaux mixture, standard dilution lime-sulphur, and unsprayed, respectively, were introduced as checks upon which to make comparisons in judging the results obtained upon the other plots.

The spraying program laid out for plots 2, 3, and 11 was suggested by the results obtained with arsenate of lead as a fungicide during the two previous seasons.* The efficiency of this material in controlling apple scab, when used somewhat in excess of the usual amount employed as an insecticide, suggested a possible modification in spraying procedure which might still control both scab and insect enemies and at the same time simplify the work of orchard spraying. This plan was to use a strong fungicidal spray combined with the usual amount of arsenate of lead when the blossom buds are showing pink, but for later sprayings to depend entirely upon double strength arsenate of lead alone for controlling both scab and insect enemies. Plot 11, sprayed with arsenate of lead alone throughout the season, was introduced in order to obtain additional data upon the fungicidal value of this material.

Plots 5 and 10 were primarily for comparison with plot 4 which was sprayed 3 times with standard dilution lime-sulphur. It is generally conceded that the application of fungicides when the blossom buds are showing pink is a very important one from the standpoint of scab control. Partly through accident this was brought out quite forcibly in the 1912 experiments. On the other hand omitting this first application of lime-sulphur in 1913 resulted in but a slight increase of scab. Hence plot 5 was introduced into the 1914 experiments to test this matter again in

*Morse, W. J. and Yeaton, G. A. Orchard Spraying Experiments in 1912. Maine Agl. Exp. Sta. Bul. 212: 69-70. 1913.

Morse, W. J. Spraying Experiments and Studies on Certain Apple Diseases in 1913. Maine Agl. Exp. Sta. Bul. 223: 13-16. 1914.

comparison with plot 4. Plot 10 was also a continuation of the work of previous years, the object being to determine whether or not it is safe and profitable to add 20 per cent more of the lime-sulphur concentrate to a given amount of water, thus increasing the strength of the summer spray to that extent.

In 1913 a proprietary spraying material in powder form, known under the trade name of "Soluble Sulphur," was used at the rate of 2 pounds to 50 gallons of water in combination with one pound of dry arsenate of lead. While this material appeared to be quite effective in scab control that season very serious leaf injury resulted. Correspondence with orchardists in various parts of the State, who had used this material as a summer spray, showed that in the majority of cases they had experienced a like difficulty. Plot 6 was a repetition of the previous trial of this material, but the amount used to 50 gallons of water was reduced to three-fourths pound on the recommendation of the New England selling agents of Soluble Sulphur.

The "Atomic Sulphur" used on plot 7 is another proprietary spray material which was used in 1913.

The "copper-lime-sulphur" applied to plot 8 was a combination of spray materials used for the first time at this Station. Dr. Howard S. Reed and his associates at the Virginia Agricultural Experiment Station reported very successful results with this in their spraying experiments for cedar rust of apples in 1913.* Since no unfavorable effects with reference to foliage or fruit injury were recorded in their publication this spray combination appeared promising as a means of combatting apple scab. Therefore, it was included in the experimental series of 1914.

Plot 9, sprayed with the extra fine sulphur, was introduced at the request of a representative of the Union Sulphur Company of New York. This extra fine flour sulphur was prepared for application as a liquid spray material as per directions furnished by him as follows:

"For every seven or eight pounds of dry sulphur to be used prepare two gallons of glue solution containing one-half ounce

*Reed, Howard S., Cooley, J. S., and Crabill, C. H. Experiments on the Control of Cedar Rust of Apples. Virginia Agl. Exp. Sta. Bul. 203, 1914.

of glue to the gallon. Place the sulphur in a pail or other convenient receptacle, and pour on half of glue solution called for above, i. e., one gallon of glue solution to seven or eight pounds of sulphur. Work the sulphur into the glue solution until it is thoroughly wetted and forms a smooth, creamy mass by stirring with a stick or kneading with the hands, breaking up all the lumps as thoroughly as practical."

For straining he recommended the construction of a special strainer of wire cloth, preferably of brass, 10 or 12 meshes to the inch, supported by a piece of one-fourth to one-half inch mesh galvanized wire cloth, and backed by a piece of cheese cloth attached to a removable wooden frame placed in the box. According to directions the remainder of the glue solution was to be used to wash the sulphur paste through the strainer, this process to be facilitated by brushing with a cheap paint brush.

Since the main object to be attained in this straining was simply to thoroughly break up all small masses of sulphur sticking together, as well as to remove foreign bodies which might clog the spray nozzles, a more simple method of straining was tried with fair success. In this the ordinary strainer used for straining other spray materials was employed. This strainer is a rectangular box, open at the top. One of two opposite sides of this box is several inches shorter than the other, so that the bottom of the strainer, which is covered with strong brass wire cloth, about 40 meshes to the inch, forms an acute angle with the sides. By rubbing with the hands or a piece of shingle most of the sulphur was worked through this strainer with the remaining glue solution, and what was left was readily washed through with ordinary water from a hose.

As a rule this sulphur and glue paste after straining and diluting was immediately placed in the spray tank and applied. If allowed to stand for a time after straining the sulphur would settle and form a rather stiff paste or semi-solid mass at the bottom of the container, but no difficulty was experienced in again bringing it into suspension in condition to be diluted for final application.

TIME AND MANNER OF APPLICATION.

Except as mentioned below the spray applications to the different plots were all made on the same day. Especial care

was taken to make the method of application as nearly uniform as possible. A gasolene power sprayer was used, carrying 2 leads of hose with each extension rod equipped with 2 nozzles. Approximately 150 pounds of pressure per square inch was maintained. While this pressure is less than that frequently recommended a fine mist was obtained from the nozzles, which appeared to be entirely satisfactory. Care was taken to see that each tree was thoroughly and evenly sprayed at each application, but not enough to cause excessive dripping. After each plot was sprayed the spray tank, pump, hose and extension rods were thoroughly rinsed with clean water.

The first application was begun on Saturday, May 23 and finished on Monday, May 25. Conditions during the previous week seemed to indicate that spraying the entire plot might be delayed until the latter date, but toward the last of the week the flower buds began to develop quite rapidly. They were just beginning to show pink on some of the trees on the 22nd. Saturday morning, May 23, was cloudy with slight rain. The afternoon being clear it was decided to begin spraying, and applications were made to plots 3 and 4. As has already been stated the remaining plots were sprayed on Monday the 25th. The 24th was clear, but the 25th was more or less cloudy with a slight trace of rain in the evening following.

The second application was made on June 6, immediately after the petals had fallen, the third on June 22, slightly more than 2 weeks later.

EFFECT OF THE DIFFERENT SPRAYS ON FOLIAGE AND FRUIT DURING THE SUMMER.

The development of scab. No scab was observed on any of the plots until after June 23. Its first appearance on the foliage occurred between this and June 30, or in the week following the third spray application. On the latter date it was recorded as common on the unsprayed check plot and present to a slight extent on some of the others. The following is a brief summary of the weekly or semi-weekly notes on the development of scab on the foliage and fruit up to the end of the first week in August, along with certain other records made at more or less irregular intervals between this and harvest time.

On plot 1, sprayed with bordeaux mixture and arsenate of lead, no scab was recorded on either foliage or fruit previous to harvest time.

Plots 2 and 3, sprayed first with the strong fungicides and arsenate of lead and later with double strength arsenate of lead alone, showed a slight amount of scab on the foliage on June 30, and a similar record was made with reference to the fruit on July 21, but there was very little increase throughout the season.

The records for plot 4, sprayed with standard dilution lime-sulphur, plot 5, sprayed the same as plot 4 with the first application omitted, and plot 6, sprayed with Soluble Sulphur, were also nearly identical. A slight amount of scab was observed on the fruit on July 14 and the same thing was noted for the leaves on July 21, with no material increase as the season progressed.

On plot 7, where the Atomic Sulphur was used, scab was recorded as slight on the leaves on June 30, July 7 and 14; quite common on July 21, and abundant on July 28. On this plot it was first observed on the fruit to a slight extent on July 14 and did not increase materially during the season.

No scab was observed on either foliage or fruit on plot 8, sprayed with the copper-lime-sulphur mixture, during the season.

On plot 9 where the extra fine sulphur was applied the disease was first noted on the leaves as slight on June 30. Very little increase was observed up till July 28 when scab was recorded as plentiful, and also as occurring to some extent on the fruit.

Where the stronger lime-sulphur was used on plot 10 no scab was observed on the leaves till July 28 when a very slight amount was noted. A little had been previously recorded on the fruit on July 14.

On plot 11, sprayed with double strength arsenate of lead alone, it was very evident throughout the season that scab was more common on both leaves and fruit than on the plots sprayed with the regular fungicides. It was also more common than had been the case where the same treatment had been made in previous years. However, it was also equally evident that it was materially less than on the unsprayed check plot which stood beside it, although it was first recorded on both of these plots on the same date.

Scab was first recorded on the foliage on the unsprayed check plot on June 30, and abundant on both leaves and fruit on July 7. This condition prevailed throughout the season.

Spray injury during the summer. Where bordeaux mixture was used on plot 1 no spray injury was noted till July 7, or something over 2 weeks after the third application had been made. At this time russetting had begun to appear on the young fruit, but there was no spotting of the leaves. However, foliage injury developed quite rapidly during the next week, and by July 14 many of the leaves were badly spotted and a few were beginning to turn yellow and drop off. This defoliation increased during the month and on the 5th of August it was estimated that at least one-third of the leaves had fallen and that the total number of injured ones represented at least 50 per cent. At harvest time nearly all evidence of early leaf injury had disappeared. At this time while the foliage was noticeably less dense, and some of the older leaves showed some spotting, the general effect was such as to give the impression that the foliage on this plot was more strong and vigorous and of a richer green than on any other plot in the series.

With regard to spray injury some very interesting observations were made on plot 2, sprayed with a 3-3-50 bordeaux mixture when the blossom buds were showing pink and later with arsenate of lead alone, at the rate of 2 pounds of the dry powder to 50 gallons of water. The first evidence of any injury was noted on the same date, July 7, that it was observed on the adjoining plot sprayed 3 times with bordeaux mixture. At this time the record shows "Doubtful russetting of the fruit." A slight russetting was plainly evident on July 14, and this increased somewhat during the remainder of the season. Slight leaf injury was recorded on July 21, but this did not amount to much then or thereafter. The foliage was very vigorous and healthy at harvest time. Attention is called to the fact that, as is recorded below, no such injury was observed on plot 11 which was sprayed with double strength arsenate of lead for all 3 applications. Also, as is shown in the detailed record of the condition of the fruit at harvest time, relatively few russeted apples were produced on the last named plot. The possible significance of these observations is considered later in the discussion of results.

The most serious leaf injury of all was obtained on plot 6, although, as has already been stated, the amount of Soluble Sulphur in 1914 was reduced to three-fourths pound to 50 gallons of water. Not only was this leaf injury more severe, but this injury occurred much earlier where Soluble Sulphur was applied than anywhere else, being first observed on June 6 before the second application of the sprays. At this time a considerable number of the leaves had turned brown at the edges and brown circular spots had begun to appear on various parts of them.

This injury increased very rapidly, and was followed by partial defoliation of the trees. On June 18, 10 days after the second application, the ground under these trees was from one-third to one-half covered with fallen leaves. By the last of June it was estimated that at least one-third of all of the leaves on the trees sprayed with Soluble Sulphur had fallen. The more severely injured leaves continued to fall gradually through July, but defoliation had largely ceased by the first week in August. The total leaf-fall early in the season undoubtedly amounted to considerably over 50 per cent of the foliage present at the time of the last application, but growth later in the season made this somewhat less apparent.

No russetting of the fruit was observed on the Soluble Sulphur plot during the season.

Severe foliage injury also occurred on the plot sprayed with the copper-lime-sulphur. It did not begin quite so soon as where Soluble Sulphur was used but was nearly as severe. It differed from the injury produced by the latter in that it first appeared as more of a spotting and less of a burning of the margins of the leaves. Also rapid defoliation did not occur so early in the season but the final outcome in this last respect was nearly the same. The injury caused by the copper-lime-sulphur more closely resembled that produced by bordeaux mixture.

In another respect the effect of the copper-lime-sulphur spray was similar to that of bordeaux mixture. Injury to the fruit was noted when the latter was quite small, which developed into a marked russetting later in the season.

What was thought to be a slight burning of the margins of the leaves was noted on plot 10 after the first application of the stronger lime-sulphur, although nothing of the kind was

recorded for plot 3 where the first spray application was identical with that on plot 10. No other evidence of spray injury on foliage or fruit was observed on plot 10 previous to harvest time.

No leaf injury could be detected on plots 3, 4, 5, 7 and 11 during the season and whatever fruit russetting was present on any of these plots was not sufficiently prominent to be noted in the field.

THE EFFECT OF THE DIFFERENT SPRAYS ON THE FRUIT.

The apples on the experimental plots were harvested on October 7 and 8 and were immediately sorted into 3 classes,—namely, the number of smooth or perfect apples, the number scabby and the number russeted.

Except in the case of plot 1, the sample from which to obtain this sorting record consisted of 20 barrels of fruit selected at random from the crop produced on the two central rows of trees on each plot. By rejecting the crop on the two outer rows it was felt that the effects of the sprays drifting with the wind from adjoining plots was largely eliminated. In the case of plot 1, sprayed with bordeaux mixture and consisting of but 3 rows, the 20 barrels used for sorting came from the central row and the inner half of each tree on the two outside rows.

The following is a tabulated summary of the results obtained from sorting and counting the number of fruits on each of the different plots. The percentages of smooth, scabby and russeted fruits do not always total 100 for in some instances apples were found which were both scabby and russeted and were therefore counted twice.

All apples which showed any traces of scab, however small, were classed as scabby. No attempt was made to separate these into classes showing different degrees of scabbiness, for it was felt that the fundamental question under consideration was the relative efficiency of the different spray materials in the prevention of disease under conditions as near alike as they could be made in an ordinary field experiment. Therefore, it would seem that the only basis upon which this could be judged, which would eliminate matters of personal judgment, is whether or not scab was present in any degree. On the other hand no

apples were classed as russeted unless this was plainly evident,—that is, apples which showed minor scars and imperfections of the skin, not plainly suggestive of spray injury, were classed as smooth.

The senior writer has been interested in watching the development of these various injuries and imperfections which appear on the skin of growing apples and has followed individual cases through a number of different seasons. He is convinced that many of these minor imperfections are due to slight mechanical injuries or to insect attacks, often when the fruit is quite young and small, and particularly from the egg-laying punctures of the curculio. In the fall imperfections on the surfaces of apples resulting from injuries produced by this insect earlier in the season have been found in the orchard in question, varying from the typical crescent-like scars through various steps and graduations up to large blotches of russetting in which all evidence of the original puncture had disappeared and where the outline had become so modified as to practically obliterate the distinct crescent form of the original injury.

Summary of Results Obtained from Sorting Fruits.

Plot No.	Treatment.	Total number of apples.	Number smooth.	Number seamy.	Number russeted.	Per cent of perfect apples.	Per cent of seamy apples.	Per cent of russeted apples.	Difference in per cent of russetting as compared with check.
1	Bordeaux mixture, 3-3-50, plus 1 lb. dry arsenate of lead to 50 gallons.	*8,070	833	24	7,217	10.32	0.3	89.43	89.24
2	First application like plot 1. Later applications 2 lbs. dry arsenate of lead to 50 gallons of water.	6,611	305	1,218	81.84	3.78	15.08	14.88	
3	First application lime-sulphur 20% stronger than standard, plus 1 lb. dry arsenate of lead to 50 gallons. Later applications like plot 2.	7,578	7,278	150	96.0*	1.98	1.98	1.78	
4	Standard dilution lime-sulphur plus 1 lb. dry arsenate of lead in 50 gallons	*7,250	6,808	109	336	93.9	1.5	4.63	4.43
5	Like plot 4 with first application omitted.	8,629	8,483	104	42	98.31	1.2	0.49	0.29
6	Soluble Sulphur 1 lb. and dry arsenate of lead 1 lb. to 50 gallons of water.	*7,807	7,578	68	164	97.07	0.87	2.1	1.9
7	" Atomic Sulphur 7 lbs. and dry arsenate of lead 1 lb. to 50 gallons of water.	7,582	7,506	67	9	99	0.88	0.12	-0.08
8	Standard dilution lime-sulphur plus copper sulphate 2 lbs. and dry arsenate of lead 1 lb. to 50 gallons.	*7,795	3,193	154	4,484	40.96	1.98	57.52	57.32
9	Extra fine sulphur 10 lbs. plus dry arsenate of lead 1 lb. in 50 gallons of water.	*9,007	8,177	292	544	90.78	3.24	6.04	5.84
10	Lime sulphur 20% stronger than standard dilution plus 1 lb. dry arsenate of lead to 50 gallons.	*8,043	7,425	53	568	92.32	0.66	7.06	6.86
11	Dry arsenate of lead 2 lbs. alone to 50 gallons of water.	*8,814	8,266	443	107	93.78	5.03	1.21	1.01
12	Unsprayed check.	*8,579	7,478	1,085	17	87.17	12.65	0.2	

* Omitting those fruits counted twice—both seamy and russeted.

DISCUSSION OF RESULTS.

Since the spraying experiments for 1914 were either planned largely as the result of tentative conclusions derived from data previously secured or are repetitions of those carried out in one or both of the two preceding years it is necessary to consider the latter in discussing the results of the work of the past season.

Efficiency of the first spray application: Some writers have laid great stress upon the importance of the spray application made when the flower buds are showing pink as well as upon the necessity of being ready to apply this within the limits of one or two days. This attitude is undoubtedly the correct one with reference to many seasons and for many localities. The writers do not wish to be understood as recommending that Maine orchardists be less vigilant or less prompt in applying the so-called "pink spray" but the results obtained for the past two seasons show that if circumstances arise which delay its application or cause it to be omitted altogether the apple grower need not necessarily feel that his spraying operations for the current year will result in a failure in scab control, provided the other, later applications are made in due time.

In 1913 and 1914 the unsprayed check plots produced 38.8 and 12.65 per cent of scabby apples respectively. The plots sprayed 3 times with standard dilution lime-sulphur gave 3.15 and 1.5 per cent of scabby fruit while on the adjoining plot in each case where the first application was omitted the per cents were 6.32 and 1.2 respectively. In other words omitting the pink spray entirely in 1913 resulted in some increase of scab when compared with the plot where it was not so omitted, but when compared with the unsprayed check plot it was shown that over five-sixths of the probable amount of scab development had been prevented—a condition far from a total failure. Moreover from the records obtained in 1914 it will be seen that no increased efficiency in scab control was obtained from the first application of the spray which was made on plot 4 sufficiently early to give ample protection. In fact the amount of scab was actually less where it was omitted, but the difference was slight and within the limits of experimental error.

In this connection it is only fair to call attention to the results obtained in 1912. Not only was apple scab more severe that season, but apparently weather conditions and other influencing

factors were particularly favorable for scab infection at the blossoming period. Hence the results secured by omitting the first fungicidal spray were most striking. Three applications of standard dilution lime-sulphur gave almost perfect scab control, there being only 1.4 per cent of affected fruits at harvest time. Where the first of these applications was omitted 47.6 per cent of scabby apples were obtained. However, even here the amount of scab was materially reduced, but this can only be judged approximately, for the only available check plot was one sprayed with 2 pounds of arsenate of lead paste (approximately equivalent to one pound of the dry powder used during the past 2 seasons) in 50 gallons of water. Somewhat over 80 per cent of the fruit on this plot was scabby at harvest time. Our work during that season and the two following has shown that double this quantity of arsenate of lead is of material value as a fungicide for apple scab. Also the results obtained in 1913 indicated that even so small an amount of arsenate of lead as was used on this so-called check plot in 1912 might materially reduce the amount of scab and consequently make a plot sprayed in this way unreliable as a basis for comparison in judging the efficiency of a fungicide used on another plot.

Different dilutions of lime-sulphur. Last season was the third where different dilutions of lime-sulphur were tested, in which apple scab developed to a sufficient extent to judge their efficiency. Earlier work indicated that under Maine conditions it was not safe to use a weaker dilution than that commonly employed, or what is referred to throughout this publication as "standard dilution." From the work of the three seasons it would seem that on the Ben Davis, a variety well-known to be easily injured by bordeaux mixture, at least 20 per cent more of a lime-sulphur concentrate than is commonly employed may be used to make a given amount of spray and be used with comparative safety.

With this stronger dilution a slight amount of leaf injury has been observed occasionally and the amount of fruit russetting has been somewhat increased, particularly last season where it was increased from 4.63 to 7.06 per cent when compared with the plot sprayed with the weaker dilution. Therefore there might be some question about using the stronger spray for the later applications.

As might be expected the stronger lime-sulphur has invariably produced better scab control than the standard dilution. In 1912 when scab was more severe this increase in efficiency much more than paid the extra cost for spraying material.

Lime sulphur vs. bordeaux mixture. As has already been stated plots 1 and 4, particularly the former, were introduced chiefly for the purpose of comparison. Attention is called to the fact that again bordeaux mixture showed the greatest efficiency in scab control, but far outranked all of the other spraying materials in the amount of russetting produced. On account of russetting only a little over 10 per cent of perfect apples were obtained where bordeaux mixture was applied while nearly 94 per cent of the same grade of fruit was harvested where the standard dilution lime-sulphur was used.

"Soluble Sulphur." The results secured in 1914 with this material fully confirm the tentative conclusions derived from the experiments of the previous year and from letters received from orchardists who used Soluble Sulphur as a summer spray that season. Even when reduced to three-fourths pound and used with one pound of dry arsenate of lead in 50 gallons of water it again produced most serious defoliation. In view of these results it therefore cannot be recommended and cannot be used with safety with arsenate of lead as a summer spray for apple trees.

In justice attention should be called to the fact that during both seasons in which this material has been tested very efficient scab control has been secured and the amount of fruit russetting compared very favorably with that resulting from the use of standard dilution lime-sulphur.

"Atomic Sulphur." The condition of the fruit at harvest time on the plot sprayed with this material was, as in the case of the previous season, quite satisfactory. Scab control on the fruit was very efficient and the amount of russetting was actually less than on the unsprayed check plot. The control of scab on the leaves was by no means as good as the previous season.

Arsenate of lead as a fungicide. The results secured in 1912 and 1913 indicated that arsenate of lead for apple scab has considerable fungicidal value. Our attention was first called to this fact when it was found in 1912, a season in which scab development was particularly severe, that a plot sprayed with

4 pounds of arsenate of lead paste alone in 50 gallons of water showed as good scab control as where other plots were sprayed with half of this amount of arsenate of lead combined with recognized fungicides, exceeding that obtained from bordeaux mixture and standard dilution lime-sulphur and only being equalled by the stronger lime-sulphur.

In 1913 where 2 pounds of the dry arsenate of lead was used in 50 gallons of water scab was better controlled than on any of the other plots except where bordeaux mixture and the stronger lime-sulphur was used in combination with one pound of the insecticide.

Reference to the tabulated results shows at once that in 1914 arsenate of lead was less efficient in controlling scab than during the two preceding years. This fact was also apparent from the condition of the foliage and fruit on the trees all through the season. However, while these results are not so favorable they by no means contradicted those of previous years. This fact is also shown in the later discussion of the results secured on plots 2 and 3 where only double strength arsenate of lead was used after the first application. On account of freedom from russetting the per cent of perfect apples on plot 11 where the double strength arsenate of lead was used was fully equal to that obtained on plot 4, sprayed throughout the season with standard dilution lime-sulphur, combined with one pound of arsenate of lead in 50 gallons.

In connection with the discussion of arsenate of lead used alone as a fungicide it should be mentioned that some results reported from certain other parts of the country last season were less favorable than those previously secured at this Station. Jackson and Winston in Oregon make the following statement: "Double arsenate of lead, when used throughout the season uncombined with fungicide gave negative results as a remedy for scab."* However, Professor Winston in a letter to the senior writer under date of April 15, 1915, says: "In regard to arsenate of lead you might infer that it is of no value to us as a fungicide; our figures would indicate that, however, I have been told by certain orchardists that they received very

*Jackson, H. S. and Winston, J. R. Report of the Hood River Branch Experiment Station for 1913-1914: 17, Oregon Agl. Col. Exp. Sta. 1915.

nice control of scab by the use of double strength arsenate of lead in the calyx and subsequent applications where lime-sulphur or bordeaux had been used in the pink." He then goes on to state that certain factors, particularly of a local, climatic nature which influenced the results of the experimental trials should be taken into consideration in interpreting the figures obtained.

Dr. W. L. Howard of Missouri reported that in 1914 in the case of an acre of Jonathan trees sprayed with arsenate of lead alone the amount of cedar rust was reduced one-half.* There was, however, a large amount of russetting of the fruit on this plot which could not be accounted for except that it came from bordeaux mixture which had been previously used in the spray tank and not entirely removed. He suggests the possibility that the scab control might be attributed to the same material.

Professor Howard writing under date of April 20, 1915, says: "I have long felt that arsenate of lead possessed some fungicidal value, particularly against such apple diseases as scab and fly speck or sooty mold. Also, some of our fruit growers in the Missouri peach belt feel that arsenate of lead contributes materially toward the control of brown rot, aside from its value as an insecticide in poisoning the curculio."

In a previous publication the senior writer has called attention to the fact that other observers have also reported that arsenate of lead alone, or in combination with lime-sulphur, contributed either directly or indirectly to the control of certain fungous diseases of the apple and the peach.†

Arsenate of lead alone for calyx and later applications. The very favorable results secured with arsenate of lead as a fungicide for scab suggested a possible modification of spraying methods by which the work might be materially simplified without decreasing the efficiency. This plan was to use bordeaux mixture or the stronger dilution lime-sulphur when the blossom clusters were opening and the buds showing pink, but for later applications to depend entirely upon double strength

*Howard, W. L. Profits from Spraying Twenty-five Missouri Apple Orchards in 1914. Mo. Agl. Exp. Sta. Bul. 124: 272. 1915.

†Morse, W. J. Spraying Experiments and Studies on Certain Apple Diseases in 1913. Maine Agl. Exp. Sta. Bul. 223: 14. 1914.

arsenate of lead for protection against both scab and insect enemies.

Plots 2 and 3 in 1914, conforming to this program, produced some very interesting results. It is of particular interest to compare the figures obtained on plot 3, sprayed first with the stronger lime-sulphur and later with double strength arsenate of lead alone, with those secured from plot 4 along side of it and sprayed throughout the season with a combined lime-sulphur and arsenate of lead of ordinary strength. While scab control is slightly better on plot 4 there was more russetting of the fruit. Consequently the net result in percentage of perfect apples is in favor of the arsenate of lead alone for the later applications. The same thing is found to be true when the number of perfect apples on plot 3, 96.04 per cent, is compared with that obtained on plot 10, 92.32 per cent, which latter was sprayed throughout the season with the stronger lime-sulphur and the smaller amount of arsenate of lead. In this connection attention is again called to the results obtained on plot 5, where the first application of lime-sulphur was omitted, as compared with plot 4. This comparison indicates that for the season of 1914 on this farm, undoubtedly largely on account of weather conditions in May, that the first fungicidal spray had little to do in the prevention of apple scab. This therefore, emphasizes the part played by the arsenate of lead in reducing the amount of scab on plot 3, adjoining plot 4 on the other side.

On the whole it cannot be denied that the results obtained from the use of lime-sulphur and arsenate of lead applied in this manner on plot 3 were very satisfactory. However it should be remembered that they represent only the work of a single season. At the same time these results possess added significance when considered in connection with those obtained in three successive years in testing arsenate of lead alone as a fungicide against apple scab.

As will be seen on reference to the table, the final results on plot 2 where bordeaux mixture was used for the first application were decidedly less favorable than those secured on plot 3, yet except for the first application, the spraying treatment of the two plots was identical. The amount of both scab and russetting was greater on the former than on the latter, resulting in

somewhat less than 82 per cent of perfect apples in one case as compared with slightly over 96 per cent in the other.

It is rather difficult to account for the slight leaf injury and the rather large amount of fruit russetting which occurred on plot 2. At the time the single application of bordeaux mixture was made the first foliage leaves were very small and just beginning to unfold, while the flower buds were not fully open till some few days after. The fruit russetting which occurred on this plot had every appearance of bordeaux injury, yet at first thought it hardly seems within the range of possibility that a spray applied before the blossoms open could in any way injure the fruit which set later. While it does not seem probable the only possibility in this connection is that enough of the bordeaux mixture from the early spraying, which was quite thorough, adhered to the limbs and twigs and was washed off onto the fruits by rains, after the latter had set, in sufficient quantity to cause the injury observed. Another hypothesis which has suggested itself to the writers is that sufficient bordeaux mixture from the later sprayings of the adjoining plot drifted across and caused the injury referred to. This seems improbable also for care was taken to avoid this contingency as much as possible and no trouble of like nature has been experienced in the past with adjoining plots under like conditions. Moreover the apples used for sorting came from the two inner rows on plot 2 and none from the outer row of trees adjoining those sprayed with bordeaux mixture.

The amount of russetting on plot 2 was not fully appreciated until after the fruit was harvested and the sorting began. Therefore no critical observations were made to see whether or not the rows of trees or the sides of individual trees which were most exposed to the drifting of the spray from plot 1 showed the most russetting of the fruit. There was nothing of this nature which attracted attention in making the summer observations in the field. The same experiment will be repeated during the coming season and careful observations will be made to check up this point.

Copper-lime-sulphur. This spray combination did not give any better scab control than ordinary lime-sulphur and the large amount of leaf injury and fruit russetting, over 57 per cent of

the crop in the case of the latter, was very unfavorable to it. The only conclusion which could be drawn from this single trial is that under Maine climatic conditions it is not likely to prove satisfactory when used on such tender foliage as that of the Ben Davis variety of apples.

After the first leaf injury was observed the fact was reported to Doctor Reed who replied that a statement to the effect that they did secure some spray injury on the Ben Davis in Virginia should have been inserted in their bulletin, but through an oversight this was omitted. With them the injury was less than in the case of bordeaux mixture and came largely from the earlier sprayings. The fact should not be lost sight of, however, that in different parts of the country, under different climatic conditions, the effects of a given spray on the foliage of fruit trees may be quite different.

Extra fine sulphur. While this material did not give as good results as most of the others used it showed considerable efficiency in scab control. The amount of russetting was, however, relatively high, being nearly as much as that produced by the stronger lime-sulphur when the latter was used throughout the season. In connection with the use of fine sulphur flour in suspension in water as a liquid spray mention should be made of the results obtained in New York by Blodgett and later by Reddick and Crosby with this material and with fine sulphur and arsenate of lead as a dust spray for apple orchards.* The figures presented by these writers show a material reduction of scab where fine sulphur and arsenate of lead were used alone, or combined with some inert substance used as a carrier or diluent.

*Blodgett, F. M. Experiments in the Dusting and Spraying of Apples. Cornell Agl. Exp. Sta. Bul. 340. 1914.

Reddick, Donald and Crosby, C. R. Further Experiments in the Dusting and Spraying of Apples. Cornell Agl. Exp. Sta. Bul. 354. 1915.

